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Varietal Experiments with Red Clover and Alfalfa, and Field Tests with Meadow Mixtures

BY R. J. GARBER AND T. E. ODLAND

Plats of the Meadow-Mixtures Experiment Located on the Agronomy Farm in 1923. Canvas Cock Covers Were Used on the Partly-Cured Hay

AGRICULTURAL EXPERIMENT STATION
COLLEGE OF AGRICULTURE, WEST VIRGINIA UNIVERSITY
F. D. FROMME, Director
MORGANTOWN

Varietal Experiments with Red Clover and Alfalfa, and Field Tests with Meadow Mixtures

by R. J. GARBER and T. E. ODLAND†

THE TOPOGRAPHY of West Virginia makes large areas of its agricultural land adapted primarily for hay or pasture crops. Unfortunately much of the hay produced is inferior because of choice of variety or because meadows have been allowed to "grow up" in wild grasses and weeds. The choice of kind and variety of crop is only one of several important considerations in connection with the production of hay. Drainage, cultural methods, liming, adequate fertilization, and proper curing are all essential. Such crops as sweet clover and alfalfa, for example, cannot be grown on a highly acid soil. Alfalfa seems to require a more productive soil than does sweet clover. The legumes in general are somewhat more difficult to cure than the grasses.

The purpose of this bulletin is to give the results of field investigations which were begun several years ago by the Agricultural Experiment Station to help the farmer with the proper selection of crops for hay. It will be convenient to discuss the results of the investigations in three sections — (I) Red Clover, (II) Alfalfa,* and (III) Meadow Mixtures.*

I. Red Clover

Unadapted seed has been one of the causes for the reduction in the acreage of red clover in West Virginia during recent years. This fact was illustrated in a striking manner by some experiments carried on by this Station recently.

Each year considerably more red clover is seeded than is produced in the United States; hence it is necessary to import seed from foreign countries. In West Virginia very little red clover seed is produced, although the South Branch Valley and the Eastern Panhandle do produce some seed. The total amount of red clover seed produced locally, however, does not nearly meet the demand in the state; consequently seed must be shipped in from other sources. In view of this situation the question of adaptability of seed becomes highly important. The experiment reported herein was undertaken to determine for West Virginia the relative adaptability of red clover seed from various sources.

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†Formerly associate agronomist at the West Virginia Agricultural Experiment Station; now agronomist at the Rhode Island Agricultural Experiment Station.

*The authors are indebted to D. R. Dodd, formerly assistant agronomist at the West Virginia Station, for general supervision of the alfalfa and meadow experiments in 1929.

SOURCE OF SEED

Seed from strains of red clover grown in different sections of the United States and in several foreign countries was obtained through the Office of Forage Crops and Diseases, United States Department of Agriculture, from Wisconsin, Idaho, Ohio, Tennessee, Michigan, Oregon, France, England, Chile, Roumania, Hungary, and Italy. The performance of strains from such widely separated sources should give a fairly trustworthy index of differences with reference to adaptability to West Virginia conditions.

METHODS

Each strain of clover was seeded with oats in three 1/80 acre plots systematically distributed. The oats was seeded at the rate of 1 bushel per acre and was cut early for hay. The clover was seeded at the rate of 15 pounds per acre. All clover plots were clipped late in the summer of the year they were established and the clippings were permitted to remain on the ground.

During the second year two crops of hay were obtained. At the time the field weights of the hay were determined, samples were collected and placed in the drying house to ascertain the amount of moisture carried. Later the yields of hay in tons per acre were calculated on the basis of 15 percent moisture and they are so expressed in Table 1.

TABLE 1—*Average percentage of winterkilling and of weeds in hay, and yields in tons per acre of clover strains from various sources grown at Morgantown, West Virginia, in 1926-28*

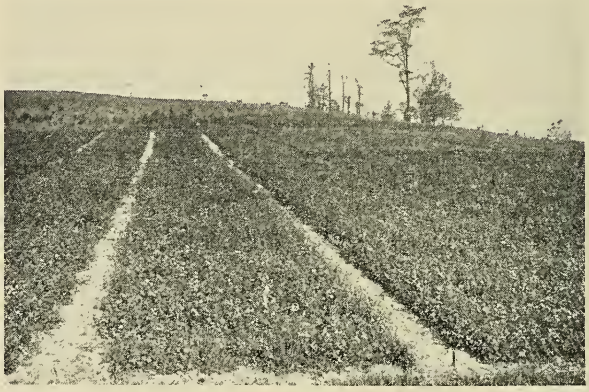
Source	No. of years in test	Total no. of plots for test	Average winter-killed	Average weeds in hay		Average yield in tons per acre		
				First cutting	Second cutting	First cutting	Second cutting	Total
Column: (1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
			percent	*percent*	*percent*			
Ohio	3	9	12	5	6	1.22	1.16	2.38
Wisconsin	3	9	4	5	7	1.20	1.08	2.28
Michigan (Check)	3	30	9	6	10	1.23	1.00	2.23
Tennessee	3	9	4	4	5	1.06	1.13	2.19
Idaho	3	9	12	6	6	1.16	1.02	2.18
Oregon	3	9	18	12	25	1.03	0.84	1.87
Chile	3	9	46	31	48	0.85	0.37	1.22
France	3	21	41	37	59	0.83	0.39	1.22
Roumania	3	9	18	19	40	0.82	0.38	1.20
Hungary	3	9	21	28	47	0.82	0.36	1.18
England	2	6	32	28	45	0.63	0.43	1.06
Italy	3	9	55	61	79	0.40	0.22	0.62

Notes were taken on the estimated stand in the fall and in the following spring, on the prevalence of anthracnose before each cutting, and on the relative amount of weeds in the hay.

Three simi'ar experiments were carried on at Morgantown during the period from 1926 to 1928, inclusive. In addition, small quantities of Michigan, Italian, French, Oregon, and Roumanian seed in 1926 and of French, Russian, and Tennessee seed in 1927 were sent for trial to about 30 farmers in West Virginia.

RESULTS

In Table 1 are shown the data collected for the clover strain test at Morgantown. Average yields in tons of hay containing 15 percent moisture, average percentage of weeds in the hay, and average percentage of winter killing, together with certain other data, are presented. It will be noted from the second column of the table that all the clover strains, except the one from England, were tested during three years. The total number of plots which were employed is shown in the third column. The strain from Michigan was used as the check, which accounts for the large number of plots of this sort. Three strains of French origin were tested one year and two strains during the other two years, thus accounting for the 21 plots required for the seed from France. The number of plots of each of the other clover strains was as planned: i. e., three plots per year.



A view of the strain test with medium red clover on the Agronomy farm in 1926

The average yields of hay in tons per acre recorded in the last column of Table 1 show the Ohio strain in first, Wisconsin second, Michigan third, Tennessee fourth, Idaho fifth, and Oregon in sixth place. All of the American strains except the one from Oregon produced an average yield of hay for the two cuttings of more than two tons per acre. The Oregon strain gave an average yield more than one-half ton greater than the highest-yielding foreign strain. The seed from Chile, France, Roumania, Hungary, England, and Italy did not give satisfactory results in these tests. The seed from Italy produced exceptionally low yields and proved wholly unadapted to West Virginia conditions.

The average percentages of weeds in the hay are shown in columns 5 and 6. The second cutting of hay showed a somewhat higher percentage of weeds than the first cutting. It will be observed that the average percentages of winter killing recorded in column 4 are

correlated with average percentages of weeds in the hay. The strains of clover from foreign countries suffered more winter injury, and as a consequence the hay contained more weeds than did the hay from domestic strains. Among native strains the one from Oregon showed most winter injury and the hay contained the most weeds.

In addition to the data recorded in Table 1, notes were taken on the prevalence of anthracnose, a disease which frequently causes considerable damage in the southern part of the red-clover belt. All the foreign strains of red clover showed evidence of the disease, particularly after the first cutting. The native strains showed very little anthracnose. This was especially true of the Tennessee seed, which has been bred for resistance to this disease.

The results of the strain test with red clover carried on in cooperation with about 30 farmers in West Virginia were, in general, similar to the results obtained at Morgantown. In the former case no attempt was made, except in a few instances, to obtain careful yield records. However, general observations indicated that the particular foreign strains of red clover included in these tests did not compare at all favorably with the native strains.

II. Alfalfa

The acreage of alfalfa in West Virginia has increased particularly during recent years. However, the ratio of number of acres of alfalfa to number of dairy cows in the state is still much below that in the adjoining states of Virginia, Maryland, Pennsylvania, and Ohio. West Virginia may well increase her alfalfa acreage several-fold.

One of the important problems in connection with growing the crop is to obtain seed of a variety adapted to local conditions. Seed of common alfalfa produced under climatic conditions less rigorous than those of West Virginia is not as likely to be adapted to the state as seed of "common" produced in a cooler climate.

During the late summer of 1924 the West Virginia Station, in cooperation with the Office of Forage Crop Investigations, United States Department of Agriculture, began some varietal experiments to compare strains and varieties of alfalfa and also to compare the same variety from different sources. Most of the seed* for this work was supplied by the U. S. Department of Agriculture.

METHODS

The varietal experiments were carried out on the Agronomy farm near Morgantown. Seedlings were made in rod-row plats twenty feet long and three feet apart. The rate of seeding was twenty pounds per acre. All seed was inoculated. At harvest the end plants of a row were discarded and the balance placed in muslin bags and hung in a drying house. After the green material had been dried to a constant weight (moisture content between 1 and 2 per-

*The seed obtained from the United States Department of Agriculture was supplied through the courtesy of H. L. Westover.

cent) it was weighed and yield determined in terms of tons of dry hay per acre.

Two separate alfalfa varietal experiments were conducted. One was established in August, 1924, and the other in August, 1928. Crops were removed for three years from the former and for two years from the latter. In each year in which the experiments were under way, except in 1930, three cuttings were removed. During 1930, an abnormally dry year, only two cuttings were removed.

The soil on which these field trials were made is Dekalb silt loam of rather low productivity. At the beginning of each experiment two tons of lime per acre were applied and in addition, ten tons of manure and 200 pounds of superphosphate per acre were used as fertilizers. The plats established in 1924 received a top dressing of 200 pounds per acre of superphosphate during the spring of 1927, and the plats established in 1928 received a similar top dressing in the spring of 1930.

RESULTS OF VARIETAL EXPERIMENTS ESTABLISHED IN 1924

In Table 2 the results of the alfalfa varietal experiments are presented. In column 1 the variety names where known are given; otherwise the places of origin of the seed are used for the variety names. The state or country in which the seed was produced is shown in parenthesis. In case of "common" alfalfa the name of the state where the seed was produced is used in the variety name. The United States Department of Agriculture accession number is shown in column 2 for each strain obtained from the Office of Forage Crop Investigations. Columns 3, 4, and 5 show estimated stands, column 6 the number of plats, and columns 7, 8, 9, and 10, the average yields of dry hay per acre obtained during the three years, 1925 to 1927, inclusive. It should be noted that yields are expressed on the basis of dry hay, not air-dry hay. The latter usually contains from 15 to 20 percent moisture. The yields of dry hay are therefore considerably lower than they would be if expressed as air-dry hay.

The varieties Lebeau, from Michigan, and Cossack, from Montana, produced the greatest average yields (2.22 tons) of dry hay per acre for the three-year period, 1925 to 1927, inclusive. The Grimm variety, from Minnesota, gave an average yield only 0.1 of a ton less than the heaviest yielders among those tested. The average yields of Cossack and Baltic, both from South Dakota, also gave average yields in excess of 2 tons per acre. Other varieties which proved satisfactory in this experiment and which are commercially available are, in descending order of their average yields: Canadian Variegated from Ontario, Common from Utah, Common from Nebraska, Grimm from both Montana and South Dakota, and Common from South Dakota. The Common seed from Kansas gave an average yield (1.69 tons per acre) somewhat less than any of the other Common seed mentioned. In fact, one of the most interesting facts brought out by Table 2 is the variation in yields of Common alfalfa

TABLE 2—*Yields and estimated stands of alfalfa varieties and strains grown on the Agronomy farm from 1925 to 1927, inclusive*

Name and place grown	U. S. number	Estimated stand in percent			No. of plats	Yield per acre in tons dry hay			Average yield per acre, tons dry hay
		Spring 1925	Spring 1926	Spring 1927		1925	1926	1927	1925-26-27
Column: (1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*
Lebeau (Michigan)	2347	81	92	88	5	2.05	2.59	2.02	2.22
Cossack (Montana)	.....	96	99	95	2	2.18	2.69	1.78	2.22
Grimm used as check (Minn.)	.....	87	84	82	35	2.03	2.50	1.84	2.12
Cossack (South Dakota)	2352	97	93	89	5	1.98	2.48	1.72	2.06
Baltic (South Dakota)	1830	93	93	82	5	2.06	2.37	1.71	2.05
Sennpalatinsk (So. Dakota)	.....	99	94	82	2	2.01	2.58	1.35	1.98
Canadian Variegated (Ontario)	2237	97	93	87	5	1.97	2.37	1.55	1.96
Utah Common (Utah)	2234	67	78	79	5	1.69	2.30	1.88	1.96
Cossack (Montana)	.....	96	95	82	2	2.19	2.56	1.12	1.96
South Dakota Common (Nebr.)	.....	89	92	92	3	1.78	2.25	1.73	1.92
Grimm (Montana)	.....	94	89	80	5	1.75	2.26	1.69	1.90
Grimm (So. Dakota)	514	91	86	81	5	1.80	2.12	1.70	1.87
Cossack (Montana)	.....	92	95	87	2	2.06	2.41	1.06	1.84
Dakota Common, from South Dakota seedsman	552	68	90	92	5	1.54	2.14	1.80	1.83
Russian (near Ural Mts.)	28037	87	90	65	5	2.01	2.25	1.21	1.82
Siberia (Western Siberia)	32389	75	95	75	1	1.60	2.57	1.23	1.80
Cossack (Nebraska)	.....	95	93	92	3	1.83	2.50	1.05	1.79
Common, Irrigated (Nebr.)	.....	72	88	85	2	1.80	2.22	1.32	1.78
Argentine, from Maryland seedsman	2346	60	84	57	5	1.72	2.23	1.36	1.77
Grimm (Montana)	.....	92	92	82	5	1.55	2.07	1.60	1.74
Provence (France)	54731	50	75	95	1	1.44	2.10	1.59	1.71
Italian, from N. Y. seedsman	2004	38	81	80	5	1.70	2.12	1.26	1.69
Kansas Common, from Kans. seedsman	533	78	75	79	5	1.58	2.02	1.48	1.69
North Dakota (Nebr.)	.....	73	88	90	3	1.53	2.03	1.51	1.69
Russian (Kuban Russia)	38852	85	75	50	1	1.74	2.36	.63	1.58
Turkestan (Nebr.)	.....	92	89	57	3	1.84	2.10	.72	1.55
Grimm (Nebr.)	.....	94	89	85	3	1.50	1.85	1.10	1.48
Caucasus (Russia)	51157	65	90	10	1	1.70	2.30	.41	1.47
Argentine Chubut, from New York seedsman	2333	32	45	38	5	1.54	1.63	.83	1.33
French "Alps Strain" (France)	54729	15	50	35	1	1.13	1.85	1.00	1.33
Chinese (Mongolia)	31687	46	46	11	5	1.67	1.60	.69	1.32
Chilean (Northern Chile)	24210	10	40	55	4	1.20	1.54	1.18	1.31
Smooth Peruvian (Calif.)	2274	3	6	10	5	1.13	1.56	1.00	1.23
Arizona Common (Ariz.)	2273	7	23	31	5	1.03	1.27	1.26	1.19
Spanish, from N. Y. seedsman	2005	12	40	71	5	.97	1.43	.98	1.13
Provence, from Penna. seedsman	34886	82	83	10	2	1.42	1.64	.25	1.10
French (France)	54730	10	10	10	1	.69	1.53	1.06	1.09
Turkestan (Turkestan)	31333	28	25	21	5	1.10	1.47	.58	1.05
Hairy Peruvian (Arizona)	538	2	8	10	5	1.11	1.16	.61	.96
M. sativa gaetula (Algeria)	26590	50	50	30	1	.85	1.47	.51	.94
Indian (India)	31467	10	26	11	5	.84	1.04	.68	.85
Peruvian (California)	33193	10	5	10	1	.57	.86	.59	.67
Chinese (China)	38464	5	3	10	1	.38	.47	.44	.43

obtained from the several sources. Common from Arizona yielded as an average for the three-year period only 1.19 tons of dry hay, whereas Common from Utah gave an average yield of 1.96 tons during the same period. It is obvious that source of seed is a very important consideration, particularly with Common alfalfa. Unless seed has been produced under climatic conditions at least equally as rigorous as those of West Virginia, the strain or variety may prove unadapted.

In columns 3, 4, and 5 of Table 2 is recorded, in percent, the estimated average stand of plants for each variety during each of the three years. Some varieties such as Chinese (U. S. No. 38,464), Peruvian (U. S. No. 33,193), and India (U. S. No. 31,467) proved wholly unadapted; other varieties such as Caucasus (U. S. No. 51,157) and Provence (U. S. No. 34,886) came through the first two winters satisfactorily but were almost completely killed out during the third winter. In a few varieties, notably Spanish (U. S. No. 2005) and Chilean (U. S. No. 24,210), the stand of plants was estimated to have increased during the progress of the experiment. The varieties which gave the greatest average yields of dry hay for the three-year period withstood the West Virginia winters satisfactorily. Little significance can be attached to the absolute values recorded in these columns, since they are estimates. The values, however, indicate general trends with respect to winter hardiness.

RESULTS OF VARIETAL EXPERIMENTS ESTABLISHED IN 1928

In Table 3 the results are shown of the alfalfa varietal experiment established in 1928. The yields of dry hay per acre for the two-year period (column 7) show that Lebeau produced on the average the greatest quantity of dry hay (2.06 tons per acre per year). For the same period, Disco No. 28 ranked second with an average yield of 2.05 tons per acre; Common from Montana and Utah from a Utah seedsman were tied for third place with average yields of 2 tons per acre. The ten next greatest yielders in descending order are: Dakota Common, Utah Common, Kansas Common, Canadian Variegated, another Utah Common, Cossack from Utah, Cossack from Montana, Oklahoma Common, Common produced under irrigation, and Hardigan. The range in average yields of dry hay for this group of ten is from 1.92 tons to 1.86 tons per acre. Perhaps the most noticeable circumstance about Table 3 is the absence of Grimm from the heavier yielding group. The strains of Grimm gave average yields of dry hay per acre for the two-year period as follows: Minnesota strain, 1.58 tons; Utah strain, 1.62 tons; a strain from a South Dakota seedsman, 1.64 tons; Idaho strain, 1.66 tons; Montana strain, 1.66 tons; a second Montana strain, 1.71 tons; a second Utah strain, 1.72 tons; and a third Montana strain, 1.73 tons.

It will be observed that there is much less variation among the average yields of Grimm than among those of Common. Arizona Common from southern California gave an average yield of only 1.24 tons per acre. This again brings out the fact that strains of

TABLE 3—*Yields and estimated stand of alfalfa varieties and strains grown on the Agronomy farm from 1929 to 1930, inclusive*

Name and place grown	U. S. number	Estimated stand in %, spring, 1929*	No. of plats	Yield per acre in tons dry hay		Average yield per acre, tons dry hay 1929-1930
				1929	1930	
Column: (1)	(2)	(3)	(4)	(5)	(6)	(7)
Lebeau (Michigan)	2622	92	5	2.26	1.86	2.06
Disco No. 28, from S. D. seedsman	14210	97	5	2.26	1.85	2.05
Common (Montana)	.....	97	5	2.14	1.86	2.00
Utah, from Utah seedsman	2561	97	5	2.18	1.82	2.00
Dakota Common, from So. Dak. seedsman	14137	98	5	2.03	1.81	1.92
Utah Common, from Utah seedsman	2623	95	5	2.10	1.74	1.92
Kansas Common, from Kansas seedsman	14181	98	5	2.14	1.69	1.91
Canadian Variegated, from New York seedsman	14154	97	5	2.00	1.80	1.90
Utah Common (Utah)	.....	99	5	2.07	1.74	1.90
Cossack (Utah)	.....	98	5	2.09	1.69	1.89
Cossack (Montana)	.....	98	5	2.10	1.68	1.89
Oklahoma Common (Oklahoma)	14475	94	5	2.10	1.64	1.87
Common, Irrigated (Nebr.)	.....	89	5	1.99	1.73	1.86
Hardigan (Michigan)	2621	96	5	2.02	1.70	1.86
Cossack	2671	94	5	1.95	1.71	1.83
Cossack (Montana)	.....	95	5	1.93	1.68	1.80
South Dakota Common (Nebr.)	.....	99	5	1.81	1.74	1.77
Cossack (Idaho)	.....	98	5	1.88	1.61	1.74
Grimm (Montana)	.....	95	5	1.87	1.59	1.73
Grimm (Utah)	.....	98	5	1.79	1.66	1.72
Common (Idaho)	.....	90	5	1.82	1.61	1.71
Grimm (Montana)	.....	96	5	1.72	1.70	1.71
Ladak (So. Dakota)	14135	95	5	1.84	1.57	1.70
New Mexico Common (N. M.)	14470	87	5	1.86	1.52	1.69
Orenburg (Montana)	.....	90	5	1.66	1.69	1.67
Grimm (Montana)	.....	92	5	1.63	1.69	1.66
Grimm (Idaho)	.....	93	5	1.72	1.60	1.66
Grimm, from S. D. seedsman	14196	90	5	1.60	1.68	1.64
Dakota No. 12, from S. D. seedsman	2668	97	5	1.67	1.62	1.64
Grimm (Utah)	.....	95	5	1.61	1.64	1.62
Turkestan (Nebr.)	.....	91	5	1.87	1.33	1.60
Grimm, used as check (Minnesota)	.....	92	70	1.62	1.54	1.58
Cossack (Montana)	.....	93	5	1.65	1.52	1.58
Russian (near Ural Mts.)	28037	97	5	1.75	1.42	1.58
French (France)	66701	88	5	1.74	1.39	1.56
Turkestan, from Nebr. seedsman	2674	91	5	1.76	1.31	1.53
Russia (Kuban Russia)	38852	71	5	1.55	1.50	1.52
Sand Lucerne, from N. Y. seedsman	36089	62	5	1.43	1.33	1.38
Ecuador (Ecuador)	55488	62	5	1.37	1.29	1.33
Argentine, from Arg. seedsman	14160	70	5	1.52	1.14	1.33
Provence (Chile)	62079	68	5	1.41	1.25	1.33
Russia (Turkestan)	31333	55	5	1.35	1.29	1.32
Arizona Common (So. Calif.)	14469	12	5	1.31	1.17	1.24
Provence (Chubut) from Ill. seedsman	14465	51	5	1.38	.96	1.17
Italian, from N. Y. seedsman	2004	62	5	1.14	1.14	1.14
Chilean (Chile)	62077	44	5	1.14	1.03	1.08
New Zealand (New Zealand)	53448	14	5	.90	1.11	1.00
Chilean (North Chile)	24210	25	5	.91	.90	.90
Arizona Common (So. Calif.)	2638	7	5	.88	.90	.89
California Common (Calif.)	17381	12	5	.92	.83	.87
Italian (Italy)	14206	59	5	.70	.80	.75
African (Union So. Africa)	14202	5	5	.52	.82	.67
Smooth Peruvian (Arizona)	2274	5	5	.64	.55	.59
Spanish, from N. Y. seedsman	7101	10	5	.55	.54	.54
Smooth Peruvian (Arizona)	14183	2	5	.29	.25	.27
Ecuador (Ecuador)	55570	2	5	.31	.18	.24
Peruvian (Chile)	62078	1	5	.15	.18	.16

*Estimate not taken in spring, 1930.

Common alfalfa may or may not be well adapted to West Virginia conditions. In general, seed of Common alfalfa which has been produced under climatic conditions where the winters are relatively cold has proved more satisfactory than seed from sections with mild winters.

An estimate of the relative amount of winter injury among the varieties and strains is indicated in column 3 of Table 3. Here again, as in the earlier experiment, some correlation between average yield and percent stand is apparent.

COMPARISON AMONG COMMON, GRIMM, AND COSSACK VARIETIES

It is interesting to compare the performance of the strains of Common alfalfa with those of Cossack and of Grimm. In Table 4 the average yields per year of the three sorts are shown.

TABLE 4—*Average yields of the strains of Common, of Cossack, and of Grimm in the two alfalfa varietal experiments*

Variety	No. of strains	Average yields in tons of dry hay					
		1925	1926	1927	1929	1930	Average
Column: (1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
1st Experiment							
Common*	5	1.68	2.19	1.64	...	...	**1.84**
Cossack	5	2.05	2.53	1.35	...	...	1.98
Grimm	5	1.73	2.16	1.59	...	...	1.83
2nd Experiment							
Common†	10	...	...	...	2.01	1.71	**1.86**
Cossack	6	...	...	...	1.93	1.65	**1.79**
Grimm	8	...	...	...	1.71	1.64	**1.67**

*Without Arizona Common.
†Without two strains of Common from Arizona and one from California.

In the first experiment the five Cossack strains averaged greater yields in 1925 and in 1926 but averaged distinctly less than the strains of Grimm and of Common in 1927. In the second experiment the strains of Common (with three of the lowest-yielding strains eliminated) produced the greatest average yields, although the average yields of the strains of Cossack were not very much lower. On the other hand the strains of Grimm averaged distinctly less than those of Common. This may have been owing, in part at least, to seasonal influence. It should perhaps be pointed out that the reduction in average yields between 1929 and 1930 (columns 6 and 7) for the strains of Common was 0.3 tons, for those of Cossack 0.28 tons, and for those of Grimm only 0.07 tons. It is possible that if this experiment had been continued for more than two years the average yields for the entire period would have shown less difference between the strains of Common and Grimm.

III. MEADOW MIXTURES

In August 1921 a series of 96 1/40 acre plats was established on the Agronomy farm for the purpose of determining the yields of air-dry hay of several legumes and grasses, both when grown alone and in mixtures. Owing to the prevalence of sorrel (Rumex acetosella) and chickweed (Stellaria media) some of the plats were plowed and reseeded in 1922. During the summer following removal

of the first crop of hay all the plats were plowed and the entire area was cropped to sweet clover. In 1924 the sweet clover was plowed under and on August 15 the plats, with a few minor changes, were re-established. After the hay crops were harvested in 1925 the plats were again plowed and the next two years the entire area was cropped to corn in order to help subdue the weeds. In the late summer of 1928, plats of 1/80 acre each were seeded with practically the same grass and legume mixtures as had been used in previous years. Smaller plats were used so as to make land available for other purposes. Hay crops were removed in 1929 and 1930, and the average yields of air-dry hay determined.

SOIL AND FERTILIZERS

The soil on which the meadow plats were established is a Dekalb silt loam. The soil was of low productivity and acid in reaction. Before the plats were established, lime at the rate of two tons, and 16% superphosphate at the rate of 200 pounds per acre, were applied. In January of 1922 manure at the rate of ten tons per acre was spread over the plats. In August, 1923, before seeding the sweet clover, the entire area was limed again at the rate of two tons per acre, and superphosphate at the rate of 300 pounds per acre was applied. A second application of ten tons of manure per acre was made in January, 1924. No additional applications of manure or lime were made, but superphosphate was used at the rate of 200 pounds per acre per year. The relatively heavy applications of lime and manure early in the experiment were necessary because of the marked acidity and low productivity of the soil. At the time the experiment was discontinued the soil showed a slightly acid reaction (pH 6.85).

OBTAINING YIELDS

In general the meadow plats were cut when the grass or legume had reached the proper stage of development for making good hay. In the case of the mixtures the predominating grass or legume determined the time of cutting.

All yields were calculated on the basis of tons per acre of air-dry hay. When the partly-cured hay on a particular plat was weighed with a small platform scale, a sample of the material was placed in a large muslin bag and weighed on a metric balance. This sample was then hung in a drying room where it was artificially dried. Later it was taken to a well-ventilated shed and allowed to remain there for several weeks before re-weighing to determine the amount of air-dry hay.

RESULTS

The yields per acre of air-dry hay, together with the rates of seeding, are shown in Table 5. The rates of seeding are in some cases somewhat heavier than those commonly used. Relatively heavy rates of seeding were used in this experiment to insure a good stand of plants.

Because of the low productivity of the soil at the beginning of the experiment and the prevalence of weeds on some of the plats, it

TABLE 5—*Summary of yields of air-dry hay obtained from certain legumes and grasses grown alone and in mixtures on the Agronomy farm, 1922-1930*

Name and rate of seeding	Yield of air-dry hay in tons per acre							
	1922	1923	1925	1929	1930	1922-30	1922-29	1922-25
Column: (1)	*(2)*†	*(3)*	*(4)*	*(5)*†	*(6)*	*(7)*	*(8)*	*(9)*
Timothy 15 lbs.	2.42²*	1.33	2.72	t 2.95	2.28	2.34	2.35	2.16
Orchard grass 20 lbs.	1.52	0.81	2.11	t 1.34	.75	1.31	1.44	1.48
Red top 10 lbs.	1.12	0.78	1.97	t 2.75	1.29	1.58	1.65	1.29
Tall oat grass 40 lbs.	2.74²	0.84	4.24²	t 3.24²	1.38	2.49	2.76	2.61
Meadow fescue 20 lbs.	t 0.74	0.66	....	....	....	....	....	....
Perennial rye grass 30 lbs.	1.75	....	1.54	....	....	....	....	....
Italian rye grass 30 lbs.	2.13²	....	....	....	....	....	....	....
Alsike clover 8 lbs.	xt 1.18	1.11	....	2.85²	....	....	....	....
White sweet clover 25 lbs.	xo 0.97	0.91	t 3.37	1.51	....	....	1.69	1.75
Yellow sweet clover 25 lbs.	xt 0.84	1.11	t 1.85	1.32	....	....	1.28	1.27
Mammoth red clover 10 lbs.	xo 1.08	0.96	t 0.95	3.64²	....	....	1.66	1.00
Medium red clover 10 lbs.	xo 1.36	0.78	t 0.58	2.96²	....	....	1.42	0.91
Timothy 10 lbs., med. red clover 8 lbs.	xo 1.61	1.51	3.26²	3.91²	3.01	2.66	2.57	2.13
Timothy 10 lbs., mam. red clover 8 lbs.	xo 1.29	1.80	3.60²	4.49²	2.75	2.79	2.79	2.23
Timothy 10 lbs., white sweet clover 10 lbs.	xo 1.20	1.91	3.85²	3.09²	2.17	2.44	2.51	2.32
Timothy 10 lbs., alsike 5 lbs.	t 2.21²	1.41	3.71²	3.59²	2.91	2.77	2.73	2.44
Timothy 10 lbs., alfalfa 10 lbs.	t 1.79²	1.47	3.92²	....	....	....	....	2.39
Timothy 10 lbs., orchard grass 10 lbs.	t 2.34²	0.69	2.25	....	....	....	....	1.76
Timothy 10 lbs., tall oat grass 20 lbs.	t 2.99²	1.00	4.24²	....	....	....	....	2.74
Timothy 10 lbs., tall oat 16 lbs., alsike 5 lbs.	3.28²	1.10	4.47²	3.75²	1.42	2.80	3.15	2.95
Tim. 10 lbs., orch. grass 10 lbs., alsike 5 lbs.	2.71²	0.91	3.71²	3.50²	.94	2.35	2.71	2.44
Tim. 10 lbs., red top 5 lbs., alsike 5 lbs.	2.43²	1.14	3.79²	....	....	....	....	2.45
Tall oat grass 20 lbs., orchard gr. 10 lbs.	2.38²	0.81	3.88²	....	....	....	....	2.36
Tall oat grass 20 lbs., alfalfa 10 lbs.	2.49²	1.09	4.63²	....	....	....	....	2.74
Tall oat gr. 20 lbs., white sw. clov. 10 lbs.	2.83²	0.82	4.41²	....	....	....	....	2.69
Tall oat gr. 20 lbs., med. red clov. 8 lbs.	2.73²	0.96	4.20²	....	....	....	....	2.63
Orchard gr. 15 lbs., med. red clover 8 lbs.	1.57²	0.61	3.03²	....	....	....	....	1.74
Orchard gr. 15 lbs., white sweet clover 10 lbs.	1.22	0.84	2.14	....	....	....	....	1.40
Orchard gr. 15 lbs., alfalfa 10 lbs.	1.47²	0.84	3.24²	....	....	....	....	1.85
Orch. gr. 10 lbs., tall oat 20 lbs., alsike 4 lbs.	2.60²	0.91	3.91²	3.56²	1.40	2.48	2.74	2.47
Orch. gr. 5 lbs., tall oat grass 8 lbs., timothy 5 lbs., alfalfa 5 lbs., alsike 4 lbs.	2.80²	1.24	4.25²	4.03³	2.26²	2.92	3.08	2.76
Alfalfa 15 lbs., alsike 2 lbs., timothy 5 lbs.	....	....	....	4.47³	2.84	....	....	....
Alfalfa (Nebr. Common) 20 lbs.	....	....	3.31²	4.20³	2.69²	....	....	....
Alfalfa (Grimm) 20 lbs.	xo 0.99	0.90	3.59²	4.01³	2.96²	2.49	2.37	1.83

†All yields average of three plots except where noted otherwise; t = two; o = one.

*Small figures indicate number of cuttings per year, i. e. ² = two cuttings per year. In all other cases a single crop removed.

xPlowed and reseeded during late summer of 1922.

was not possible to follow the original plan in all details. The departures are indicated in the table. Total average yields are based on triplicate plats except where otherwise noted. The number of cuttings per year is also shown in the table.

PURE CULTURES

The average yields for 1923 (column 3) are all rather low because only a single cutting was removed. Perhaps the most satisfactory comparison may be made by examining the total average yields for the several periods shown in columns 7, 8, and 9. Among the pure cultures of grasses, tall oat grass produced the greatest total average yield, timothy next, red top third, and orchard grass fourth, except during the 1922-25 period (column 9), when the positions of red top and orchard grass were reversed. Meadow fescue which was grown for two years only did not give a satisfactory yield. Perennial rye grass produced 1.75 tons per acre from a single cutting in 1922 and 1.54 tons in 1925, whereas Italian rye grass yielded 2.13 tons per acre from two cuttings in 1922, the only year it was grown.

The total average yields of the clovers grown alone are rather low because only a single cutting was taken off during any one season except in 1929 (column 5), when two crops were harvested each of alsike, mammoth red, and medium red clovers. During the 1922-29 period (column 8) white sweet clover produced an average yield of 1.69 tons of air-dry hay, mammoth red clover 1.66 tons, medium red 1.42 tons, and yellow sweet clover 1.28 tons per acre. The average yield of alsike is not directly comparable with these averages as it was not grown in 1925. Considering only the average total yields for 1922, 1923, and 1929, the alsike clover produced about the same amount of hay as medium red clover. The total average yields for these three years are as follows: mammoth red 1.89 tons, alsike 1.71 tons, medium red 1.70 tons, white sweet clover 1.13 tons, and yellow sweet clover 1.09 tons per acre.

Two strains of alfalfa were grown in 1925, 1929, and 1930 — the Common from Nebraska and Grimm from Minnesota. In the mixed cultures the Grimm variety was used. The average yields obtained in 1922 and 1923 were not satisfactory and can not be considered as indicative of the yields obtainable. These low yields serve to show that alfalfa can not be grown successfully in very unproductive soil. It will be recalled that these plats were very unproductive at the beginning of the experiment. After organic matter in the form of barnyard manure, and white sweet clover, along with some superphosphate, had been added to the soil, the alfalfa produced a very satisfactory crop.

Although low yields of the Grimm alfalfa were obtained during 1922 and 1923, the total average yield for the entire period 1922-30 (column 7) — 2.49 tons per acre — compares rather favorably with the other total average yields obtained from the pure cultures and

mixtures grown during the same period. The total average yield of Grimm may be compared with that of Common for the years 1925, 1929, and 1930. During this time Grimm produced a yearly average yield of 3.52 tons of air-dry hay per acre, whereas Common produced 3.4 tons per acre.

MIXED CULTURES

In order to facilitate a comparison of the several meadow mixtures, Table 6 has been prepared. The five mixtures containing tall oat grass, but no timothy, yielded on the average 2.58 tons of hay per acre, and the eight mixtures containing timothy, but no tall oat

TABLE 6—*Average yields of air-dry hay of certain grass and legume mixtures grown during 1922, 1923, and 1925 on the Agronomy farm*

Mixture containing	Number of different mixtures	Average yield of dry hay
Tall oat grass but no timothy	5	2.58
Timothy but no tall oat grass	8	2.27
Tall oat grass but no orchard grass	5	2.75
Orchard grass but no tall oat grass	5	1.84
Timothy but no orchard grass	8	2.46
Orchard grass but no timothy	5	1.96
Tall oat grass and timothy but no orchard grass	2	2.84
Tall oat grass and orchard grass but no timothy	2	2.41
Timothy and orchard grass but no tall oat grass	2	2.10
Alfalfa and tall oat grass	1	2.74
Alfalfa and timothy	1	2.39
Alfalfa and orchard grass	1	1.85
Medium red clover and tall oat grass	1	2.63
Medium red clover and timothy	1	2.13
Medium red clover and orchard grass	1	1.74
White sweet clover and tall oat grass	1	2.69
White sweet clover and timothy	1	2.32
White sweet clover and orchard grass	1	1.40
Alsike clover and timothy	1	2.44
Mammoth red clover and timothy	1	2.23

grass, gave an average yield of 2.27 tons per acre, indicating some advantage in favor of tall oat grass. In a similar manner tall oat and orchard grass may be compared. Here the difference is more pronounced in favor of tall oat grass. The difference between the average yields of the five mixtures containing tall oat but no orchard grass, and the five mixtures containing orchard but no tall oat, is 0.91 tons per acre. The eight mixtures containing timothy but no orchard grass produced an average yield of 0.5 tons more than did the five mixtures containing orchard grass but no timothy. The two mixed cultures containing tall oat and timothy but no orchard grass gave, for the three-year period, an average yield of 2.84 tons; the two mixtures containing tall oat and orchard grass but no timothy, 2.41 tons, and the two containing timothy and orchard grass but no tall oat grass, 2.1 tons per acre. Here again is evident the superiority of tall oat over timothy or orchard grass in ability to yield.

In the legume-grass mixtures the highest average yields were obtained when tall oat was one of the components. The average yields in tons per acre of alfalfa with tall oat, with timothy, and with

orchard grass were 2.74, 2.39, and 1.85, respectively. Medium red clover with the same three grass crops and in the order named produced average yields of 2.63, 2.13, and 1.74 tons per acre. White sweet clover with tall oat grass gave an average yield of 2.69 tons of hay per acre, with timothy 2.32 tons, and with orchard grass 1.40 tons. A mixture of alsike clover and timothy produced somewhat more hay in this experiment than did the mixture of mammoth red clover and timothy.

The outstanding fact shown in Table 6 is that tall oat grass possessed marked ability to yield under the conditions of this experiment. Timothy produced greater average yields than did orchard grass both alone and in mixtures. Alfalfa gave somewhat greater yields in combination with each of the three crops — tall oat, timothy, and orchard grass — than did either medium red clover or white sweet clover in combination with each of the same three crops.

TALL OAT GRASS

Inasmuch as tall oat grass is not commonly grown in West Virginia, a brief description of the plant may be desirable. It is a deep-rooted, long-lived perennial with a "bunch" habit of growth. The flowering part of the plant or panicle resembles oats somewhat. It blooms about ten days earlier than medium red clover. This fact makes it less desirable than timothy for mixtures including either clovers or alfalfa under moist conditions. Tall oat grass should be cut promptly when it begins to bloom, for soon afterward the stems become woody and unpalatable. It should not be seeded alone for hay as it is not as palatable as timothy. Tall oat grass is sensitive to shade and does not grow well under this condition. It will perhaps produce more total dry matter on unproductive soil than any other grass although it responds readily to fertilizers and to lime if the soil shows an acid reaction. It will not do well on a wet, poorly-drained soil. In a young orchard tall oat grass may be very useful in building up the supply of organic matter.

Summary

RED CLOVER STRAIN TEST

The experiments reported here indicate very clearly that one of the causes for failure with red clover may be the use of unadapted seed. Foreign-produced seed, if unadapted, is too expensive for any West Virginia farmer, no matter how cheaply it may be bought. It is more economical to purchase native seed known to be adapted even though it may cost twice as much as unadapted seed.

ALFALFA STRAIN TEST

Varietal experiments with alfalfa were established on the Agronomy farm near Morgantown in 1924 and in 1928. In the first experiment, varieties and strains from 43 sources were compared for a period of three years, and in the second experiment, varieties and strains from 57 sources were compared for a period of two years.

The average yearly yields were based on three cuttings except in 1930, when two only cuttings were harvested.

In the first experiment the variety Lebeau was one of the two heaviest yielders and in the second experiment this variety outyielded all others. Other varieties which gave satisfactory yields and which are available commercially are: Disco No. 28, Grimm, Canadian Variegated, Cossack, Hardigan, and certain strains of Common.

If Common alfalfa is used for seed in West Virginia it is important to obtain a strain that is adapted. A wide range of adaptability, and hence of yield, was found among the strains of Common alfalfa.

MEADOW MIXTURE EXPERIMENT

Various grasses and legumes were grown alone and in mixtures on triplicated 1/40 acre plats in 1922, 1923, and 1925, and on triplicated 1/80 acre plats in 1929 and 1930, on the Agronomy farm near Morgantown. Yields of air-dry hay were determined.

Among the pure cultures alfalfa, tall oat grass, and timothy each produced an average annual yield for the five years in excess of two tons per acre. As an average of four years, white sweet clover yielded somewhat more than yellow sweet clover. During the three years 1922, 1923, and 1929 alsike and medium red clover produced about the same average yields, which were somewhat less than the average yield produced by mammoth red clover during the same years. The rye grasses, meadow fescue, and brome grass did not prove very satisfactory in this experiment. As an average of three years, Grimm alfalfa produced slightly more hay than Common alfalfa from Nebraska.

Among the meadow mixtures those containing tall oat grass gave the highest yields. Timothy and alfalfa also proved to be very satisfactory components to increase yields in the several mixtures in which they occurred. In the mixtures tested in this investigation orchard grass proved to be the least desirable component from the standpoint of yield. The meadow mixtures which produced annual average yields in excess of two tons per acre during the years 1922, 1923, and 1925 are: tall oat, timothy, and alsike; tall oat, timothy, orchard grass, alfalfa, and alsike; tall oat and alfalfa; tall oat and timothy; tall oat and white sweet clover; tall oat and medium red clover; tall oat, orchard grass, and alsike; timothy, red top, and alsike; timothy, orchard grass, and alsike; timothy and alsike; timothy and alfalfa; tall oat and orchard grass; timothy and white sweet clover; timothy and mammoth red clover; timothy and medium red clover. These mixtures are listed in the order of their yields. Tall oat, timothy, and alsike, the mixture first in the list, gave an average annual yield during the three years of 2.95 tons per acre, whereas timothy and medium red clover, the last mixture in the list, produced on an average 2.13 tons annually during the same period. The highest producing mixture during the years 1922, 1923, and 1925 yielded on the average approximately 1/3 of a ton more hay than the highest-producing pure culture, tall oat grass.